RESEARCH HIGHLIGHTS

Technical Series 01-140

2001 BUILDING FAILURES STUDY

Introduction

In Canada, building rehabilitation for roofing and wall system repairs and replacement cost an estimated $7.5 billion annually. A conservative estimate of the premature failure rate is 3 to 5 per cent, or $225 to $375 million per year. Premature failure is defined as any performance condition requiring repair or replacement of the system before the benchmark date. The building envelope was identified as particularly vulnerable to durability problems.

Exposure to costly failures is significant for building owners, home warranty programs, insurance companies and builders. For example, high-rise condominium claims were estimated to be about $20 million in 1990 for Ontario. A 2000 report for the Greater Toronto Area (GTA) found that claims are common in the first few years of a building's life, with the majority occurring in the first five years, as shown in figure 1. A high incidence of failures in British Columbia led to the insolvency of the BC and Yukon New Home Warranty Program. In the United States, the Home Owners Warranty Program became insolvent in the early 1990s due in part to substantial foundation failures. Risk management techniques are needed to reduce premature failure.

Figure 1. Average percentage of claims due to building defects

Period	Per period	Cumulative
Within 1 year	15%	15%
Within 1 - 3 years	15%	30%
Within 3 - 5 years	40%	70%
Within 5 - 7 years	25%	95%
Within 7 - 10 years	3%	98%
Within 10 - 15 years	2%	100%

Canada Mortgage and Housing Corporation (CMHC) and the Ontario New Home Warranty Program (ONHWP) had undertaken a study in 1990 to document and evaluate the incidence and magnitude of failures in 44 buildings. The findings were published by CMHC in a 1991 report, *Construction Problems in Multi-Family Residential Buildings* (http://www.cmhc-schl.gc.ca/publications/en/rh-pr/tech/90230.htm).

In 2000, CMHC undertook a second study to gain a better understanding of current key failure areas. When property managers know which areas are potentially problematic, they can ensure performance audits conducted in the first, second and seventh years pay close attention to these areas. Identifying performance issues before warranty coverage expires reduces replacement costs and avoids the cost of special assessments. This study had five objectives:

1. Summarize the most frequent deficiencies reported in 15 GTA high-rise condominium technical audits completed between 1995 and 1999.
2. Determine building failure trends and key areas of focus for design and field review to prevent claims.
3. Compare failure trends with the 1991 report *Construction Problems in Multi-Family Residential Buildings*.
4. Correlate common defects with information in CMHC's *Best Practice Guides* and identify the need for new information.
5. Identify best practice solutions for high risk of failure components.

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Methodology

The consultant used data from 15 technical audits and reviewed plans and specifications before determining the causes of the deficiencies. The small sample size permitted a comprehensive review of seven major building components:

- wall construction-precast, masonry veneer, exterior insulation finish systems (EIFS), window/wall system, curtain wall, load-bearing masonry
- roofing—membrane or shingle
- anchors and rails—support for window cleaning
- windows (punched or strip) and doors
- foundations—concrete
- parking garages—intermediate slabs, columns, ramps and walls
- balconies—concrete slabs and railings.

Most of the buildings had more than one wall type, with precast being the most common in this study at 60 per cent, followed by masonry veneer at 53 per cent, EIFS at 33 per cent and window/wall at 27 per cent. Only buildings that were in the conciliation process at the time of the research were included. It was thought that frequent deficiencies for typical high-rise condominiums where claims had not yet been paid would prove a better focus for reducing claims costs in the majority of buildings.

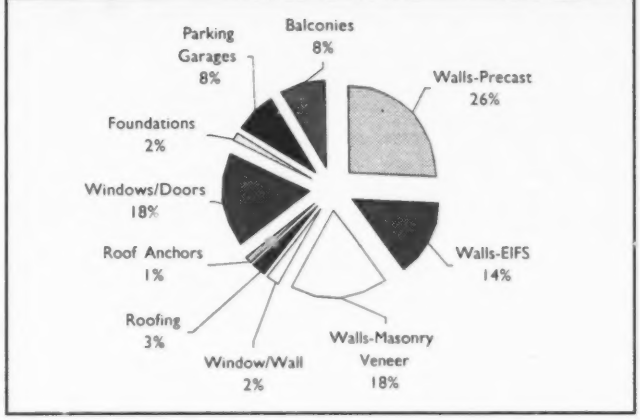
The frequency of deficiencies for each component was tabulated, and weighted adjustments were made to reflect health and safety concerns. Severe deficiencies, such as concealed leaks, that would likely result in major structural distress were adjusted by a factor of three. Moderate deficiencies that would likely cause premature leaks or health issues were adjusted by a factor of two. Cosmetic items that could easily be repaired at a minimal cost of about $1,000 were not adjusted.

An estimated cost factor was also applied. Deficiencies with a moderate degree of difficulty to correct were adjusted by a factor of two; for example, repairs involving removal of ballast, scrim sheet and insulation to access the membrane of an inverted roof. Deficiencies with a significant degree of difficulty to correct were adjusted by a factor of three; for example, repairs involving removal of landscaping, overburden and protection board to access waterproofing membrane on a parking garage roof.

Results

Using these adjustments, the relative frequency and cost of deficiencies for 10 common building components were determined, as shown in **Figure 2**.

Figure 2. Frequency and cost of deficiencies



Various solutions were proposed for the top six most frequent and costly problem areas:

Precast walls

- avoid chipped, broken, spalled or stained panels by using better shipping and handling practices, adequate concrete cover to protect reinforcing and flashing with drip edges to divert water or localized repairs;
- review samples at fabricator's shop, and test and measure concrete quality;
- correct missing or defective caulking or sealant by using compatible backer rod (closed cell foam), two-stage drained joints, 2:1 width to depth joint profiles and tooling;
- avoid inadequate drainage by using flashing projections, sealed joints, positive slope, end dams and clear drainage to the exterior;
- wall leakage is difficult to address as leakage paths tend to be indirect, but repairs usually consist of recaulking and adding localized drainage, although this is often unsuccessful.

Windows/doors

- leakage is difficult to repair, but sealants, foam, drainage vents or water diversion caps may help;
- repairs following failed air and water tests are on a trial and error basis, and retesting is required, with additional factory or lab testing sometimes necessary;

- poor window operation may be corrected by adjusting weatherstripping and hardware;
- improve condensation problems by applying additional sealants to interior components or by changing occupant lifestyle to reduce condensation levels;
- correct inadequate window drainage by clearing drainage holes, adding drainage to the exterior, adding drainage slots to inside tracks or sealing window corner joints;
- avoid caulking and sealant deficiencies with sufficient, clean adhesion areas and tooling;
- reduce staining at window corners by using end deflectors on window sills.

Masonry veneer walls

- avoid missing or inadequate air barriers by ensuring continuity at windows and using seals at slabs, corner blocking and seals at mechanical penetrations and electrical fixtures;
- avoid inadequate or missing sealant with surface preparation (cleaning), compatible backer rod (closed cell foam), bond breaker, priming, 2:1 width to depth joint profiles and tooling;
- Provide adequate expansion below shelf angles
- correct inadequate drainage with flashing projections (drip edges) on through-wall flashing, sealed flashing joints, end dams and clear drainage to the exterior;
- avoid freeze damage to brickwork and mortar with corrosion protection of shelf angles, proper securement (corrosion resistance and spacing of ties), freeze-thaw resistant brick, proper clearance from ground or exposed balcony slabs and freeze protection.

EIFS walls

- avoid inadequate or missing sealant with surface preparation (sealant should be applied to base coat) or by using a low-modulus, high-performance sealant, and ensure joint profiles have sufficient adhesion area;
- avoid damaged or cracked panels by ensuring adhesives and fasteners are used according to manufacturers' instructions, not using EIFS on horizontal surfaces, using two coats of waterproofing on metal flashing, providing freeze protection during finishing and reinforcing large openings;
- improve reviews to ensure flashing and other details are not missing or inadequate.

Balconies

- handrails (guards) are difficult to repair, but may require filler pieces to restrict openings, or removal or modification to climbing hazards;
- fastenings need to be suitably anchored, corrosion resistant and have unobstructed drainage;
- protect exterior finish from deterioration by ensuring proper concrete mix, concrete cover over reinforcing, curing and sealer or waterproofing membranes.

Parking garages

- attempts to repair leaks usually involve repeated epoxy sealing, but this traps water and can deteriorate reinforcing; ensure waterproofing membrane and traffic wearing surface are thick enough to protect slabs exposed to road salts;
- post-tensioning moisture protection is critical;
- avoid poor drainage and ponding with upturns at terminations, trench drain waterproofing, seals at penetrations, sloping to drains, good detailing at floor drains, and sloping of slab-on-grade away from structural elements.

Recommendations

Based on the findings, a number of recommendations were made regarding CMHC's *Best Practice Guides* (www.cmhc-schl.gc.ca/en/burema/himu/beprgu/beprgu_001.cfm). These include improvements to existing wall guides, specifically updating air barrier and sealant details in the brick veneer steel stud and masonry back-up guides, and adding checklists of key items.

It was also recommended that the guides focus on building components, such as exterior walls, instead of elements—such as flashing—as specific elements can differ from one system to the next. For example, sealants used with EIFS are different from those used with masonry.

The guides should cover new building envelope system solutions as they become available. *Best Practice Guides* are needed for window and doors, as these represent the second most frequent and costly source of deficiencies.

Appropriate guidelines should be established for use by professional engineers and architects for design and field review of key problem areas, and a higher level of code enforcement is required for parking garages and other requirements included in the Building Code.

Performance improvements—especially for walls, windows and doors in new buildings—should be demonstrated and assessed for cost effectiveness. Technical audits on these improved buildings should be analyzed to evaluate failures.

Performance audits should be completed for buildings less than seven years old to check for major deficiencies. Generally, building failure trends should be analyzed within about five years for new buildings and one year for conversion buildings, to assess the need for further design and construction improvements as well as the level of owner protection.

In conclusion, the 2000 research study produced an informative "big picture" view of new condominium building failures. Less is known about conversion condominiums. Without risk management procedures in place for conversions, there is a higher risk of building failures. As these buildings are only covered by builder warranties, and not a home warranty program, owners of conversion condominiums are at greater risk of incurring costly repairs.

If you have comments or if you would like to receive the complete report please contact:
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For more information about building envelope solutions and best practices that have been published by CMHC, visit the Highrise and Multiples site at:
http://www.cmhc-schl.gc.ca/en/burema/himu/index.cfm

Ontario New Home Warranty Program have also published four case ctudies intended to prevent building failures. These are available by contacting:
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Housing Research at CMHC

Under Part IX of the *National Housing Act*, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

This fact sheet is one of a series intended to inform you of the nature and scope of CMHC's research.

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